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Psaraftis, Harilaos N.

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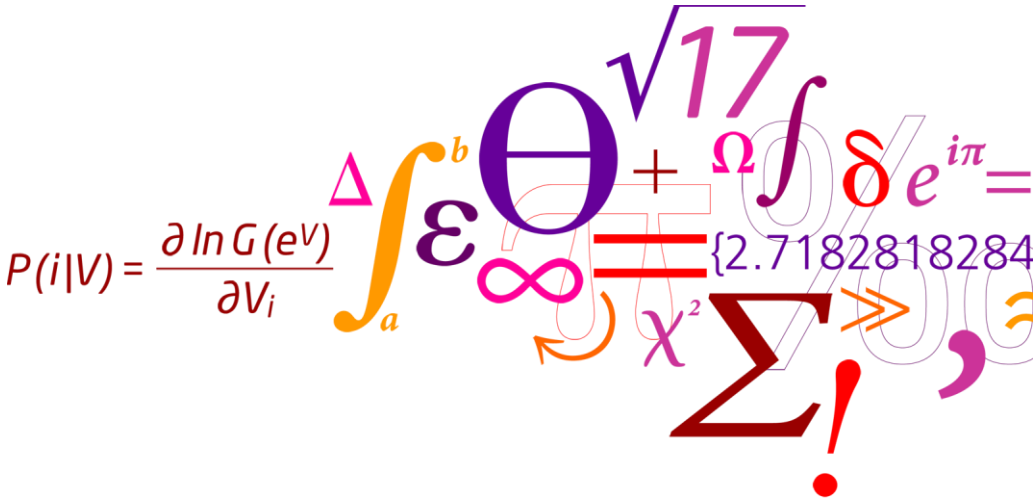
The continuing saga of GHG emissions reduction at the IMO

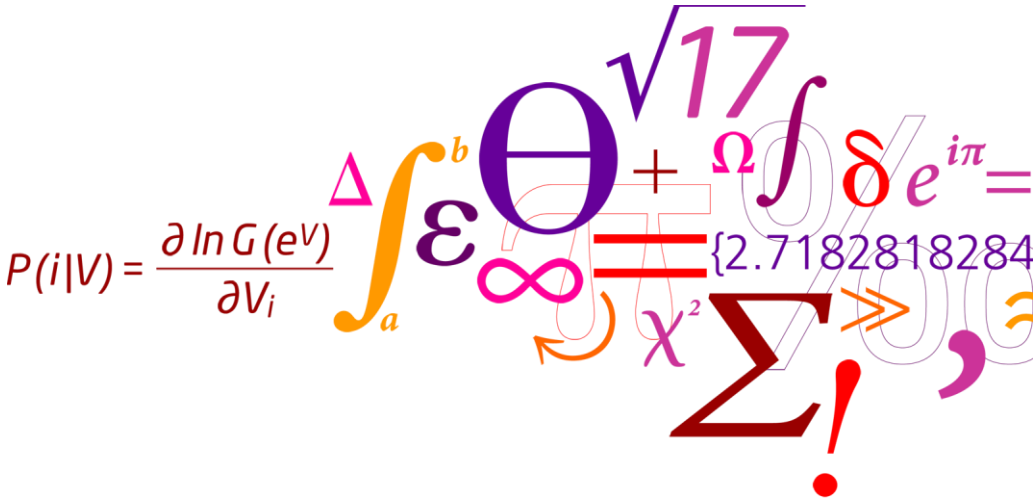
Harilaos N. Psaraftis



PREVIOUS SEMINAR: 25 OCTOBER 2018

Speed reduction vs speed optimization: the speed limits lobby strikes again

Harilaos N. Psaraftis



Q: who remembers the 25/10/2018 seminar?

Brief recap:
Big news from the IMO: April 2018!

”Initial IMO strategy”

CENTRAL AMBITION

- **Reduce annual GHG emissions by ≥ 50% by 2050** (vs 2008 levels)
- **Reduce annual CO2 emissions per transport work by ≥ 40% by 2030**, pursuing efforts towards **70%** by 2050 (vs 2008 levels)
- **Q: How?**

LONG LIST OF CANDIDATE MEASURES

HIERARCHY	EXAMPLES
• SHORT TERM (2018-2023)	• Speed reduction
• MEDIUM TERM (2023-2030)	• Market based measures
• LONG TERM (2030 on)	• Low carbon fuels

Among the short term measures

- ”Speed reduction” was proposed as a key measure
- Advocates said it can have an **immediate impact** in reducing CO2
- Can be used as a bridge until more permanent measures are in place (eg, low carbon fuels)

Speed reduction (rationale)

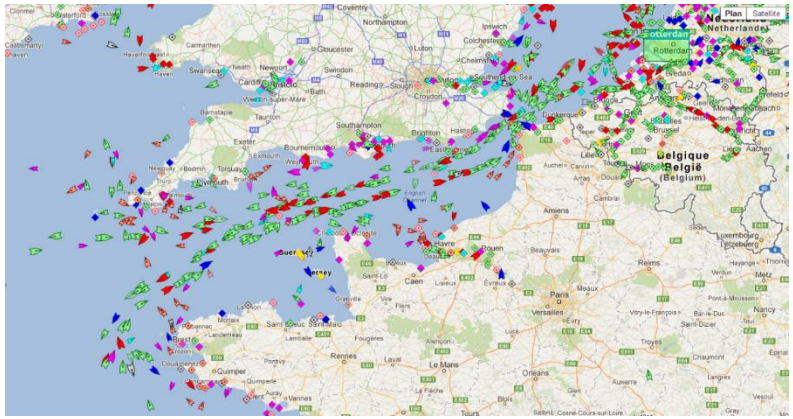
- Pay less for fuel
- Reduce emissions
- Help sustain a volatile market

- Win-win-win?
- (killing 3 birds with one stone?)

SIDE EFFECT: Build more ships to match demand throughput

- More emissions due to **shipbuilding and scrapping** (life cycle analysis)

- More maritime traffic (**less safety**)



Another side-effect

- Cargo may shift to land-based modes, if these are available
- This may result in more CO2

- European short-sea shipping
- Even in deep-sea shipping

The speed limiters lobby

- **Speed limits** have been proposed by some NGOs
- These NGOs have been lobbying the IMO and the EU for years
- Clean Shipping Coalition

25/10/2018 seminar: main result

- True that the speed limit option may buy some time within the whole IMO debate on GHGs.
- May also give a signal that looks politically correct, that the IMO has moved boldly and took a first step towards GHG emissions reduction.
- However, **it will also create many distortions and other problems** and because of this the measure should be avoided.

25/10/2018 seminar: main result ii

(personal opinion)

Speed limits VERY UNLIKELY to happen!

Q: what has happened since 25/10/2018?

A: not much

OCTOBER 2018

IMO timeplan 2018-2023

ANNEX

Streams of activity	2018	2019	2020		2021	2022		2023
	MEPC 73	MEPC 74	MEPC 75	MEPC 76	MEPC 77	MEPC 78	MEPC 79	MEPC 80
Candidate short-term measures (Group A) that can be considered and addressed under existing IMO instruments[2]	Invite concrete proposals	Consideration of proposals	Consideration and decisions on candidate short-term measures that can be considered and addressed under existing IMO instruments e.g. further improvement of the existing energy efficiency framework with a focus on EEDI and SEEMP, ITCP[3]					
Candidate short-term measures (Group B) that are not work in progress and are subject to data analysis	Invite concrete proposals	Consideration of proposals	Consideration and decisions on candidate short-term measures that are not work in progress and are subject to data analysis, consistent with the Roadmap[3]					
			Data analysis, in particular from IMO Fuel Oil Consumption DCS					
Candidate short-term measures (Group C) that are not work in progress and are not subject to data analysis	Invite concrete proposals	Consideration of proposals	Consideration and decisions on candidate short-term measures that are not work in progress and are not subject to data analysis e.g. National Action Plans guidelines, lifecycle GHG/carbon intensity guidelines for fuels, research and development[3]					
Candidate mid-/long-term measures and action to address the identified barriers	Invite concrete proposals	Consideration of proposals including identification of barriers and action to address	Progress made and timelines agreed on the development of mid- and long-term measures					
Impacts on States[4]	Invite concrete proposals	Finalization of procedure	Measure-specific impact assessment, as appropriate, consistent with the Initial Strategy, in particular paragraphs 4.10 to 4.13					
Fourth IMO GHG Study	Scope	Initiation of the Study	Progress report	Final report				
Capacity-building, technical cooperation, research and development	Development and implementation of actions including support for assessment of impacts and support for implementation of measures							
Follow-up actions towards the development of the revised Strategy		Ship fuel oil consumption data collection pursuant to regulation 22A of MARPOL Annex VI (DCS)			Initiation of revision of the Initial Strategy taking into account IMO DCS data and other relevant information			Adoption of revised Strategy

[2] Includes ongoing work pursuant to regulation 21.6 of MARPOL Annex VI.

[3] "In aiming for early action, the timeline for short-term measures should prioritize potential early measures that the Organization could develop, while recognizing those already adopted, including MARPOL Annex VI requirements relevant for climate change, with a view to achieve further reduction of GHG emissions from international shipping before 2023" (paragraph 4.2 of the Initial Strategy).

[4] Assessment of impacts on States to be undertaken in accordance with the procedure to be developed by the Organization.

OCTOBER 2018

AFTER A FIERCE DEBATE:
"prioritization" changed to "consideration"

ANNEX

Streams of activity	2018	2019	2020		2021	2022		2023
	MEPC 73	MEPC 74	MEPC 75	MEPC 76	MEPC 77	MEPC 78	MEPC 79	MEPC 80
Candidate short-term measures (Group A) that can be considered and addressed under existing IMO instruments[2]	Invite concrete proposals	Consideration of proposals	Consideration and decisions on candidate short-term measures that can be considered and addressed under existing IMO instruments e.g. further improvement of the existing energy efficiency framework with a focus on EEDI and SEEMP, ITCP[3]					
Candidate short-term measures (Group B) that are not work in progress and are subject to data analysis	Invite concrete proposals	Consideration of proposals	Consideration and decisions on candidate short-term measures that are not work in progress and are subject to data analysis, consistent with the Roadmap[3]					
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MAY 2019

This week:

ANNEX

Streams of activity	2018	2019	2020		2021	2022		2023
	MEPC 73	MEPC 74	MEPC 75	MEPC 76	MEPC 77	MEPC 78	MEPC 79	MEPC 80
Candidate short-term measures (Group A) that can be considered and addressed under existing IMO instruments[2]	Invite concrete proposals	Consideration of proposals	Consideration and decisions on candidate short-term measures that can be considered and addressed under existing IMO instruments e.g. further improvement of the existing energy efficiency framework with a focus on EEDI and SEEMP, ITCP[3]					
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IMO

Last week

- 5th Intersessional meeting of the working group to reduce GHG emissions from ships

This week

- MEPC 74

Q: what has happened since 25/10/2018?

Q: what has happened since 25/10/2018?

15 APRIL 2019

MDPI

Article

Speed Optimization vs Speed Reduction: the Choice between Speed Limits and a Bunker Levy

Harilaos N. Psaraftis

DTU Management, Technical University of Denmark, 2800 Lyngby, Denmark; hnpsar@dtu.dk

Received: 18 March 2019; Accepted: 10 April 2019; Published: 15 April 2019

check for updates

Q: what has happened since 25/10/2018?

30 APRIL 2019

Shipping industry calls for speed limits to cut emissions

The lobby for mandatory speed limits has received the backing of more th 100 shipping companies and environmental organisations. The signatories call for obligatory limits as soon as possible, but major box carriers have not signed the letter

30 Apr 2019 | **NEWS**

by Anastassios Adamopoulos

@Anastassios_LL | Anastassios.Adamopoulos@informa.com

Major shipping companies call for average speed limits on containerships and absolute limits on all other ships

Open letter to IMO Member States supporting mandatory speed measure to reduce shipping emissions

30/April/2019

Effectively addressing climate change is possibly the greatest challenge of our time. In 2015 world governments agreed in Paris that global temperature rise must be limited to well below 2°C, while aiming for 1.5°C compared to pre-industrial levels. A recent IPCC 1.5° Special Report also recommended "deep emissions reductions" to achieve these temperature goals.

In responding to this global challenge, member states of the International Maritime Organisation (IMO) agreed in April 2018 on an Initial GHG Strategy for international shipping. The strategy calls for shipping emissions to peak as soon as possible, for shipping's carbon intensity to be reduced by at least 40% by 2030 and for total emissions to be cut by at least 50% by 2050 compared to 2008, while aiming for full decarbonisation. To do so, new operational measures will need to be implemented for both the existing fleet and new ships and immediate reductions achieved by 2023.

Since the April 2018 agreement several candidate measures have been proposed including speed regulation for all ships. Recent history shows that reducing the global fleet's operational speed after the 2008 economic crash led to dramatic reductions in GHG emissions. This speaks to the real-world effectiveness of a potential prescriptive speed measure in helping achieve reduction targets. However, recent studies also suggest that ships are speeding up again as global demand recovers. Should this trend continue, any GHG gains from slow steaming over recent years will disappear.

The signatories to this letter unite in stressing the urgent need for shipping to make its appropriate contribution to addressing climate change. As the initial step we express our strong support for the IMO implementing mandatory regulation of global ship speeds differentiated across ship type and size categories. Our preference would be to set maximum annual average speeds for container ships, and maximum absolute speeds for the remaining ship types, which take account of minimum speed requirements. Such a regulation should be implemented as soon as possible and the obligation for compliance should be placed both on shipowners and operators, including charterers.

We call on all Parties at the forthcoming MEPC74 to support this move.

SIGNATORIES

Parenthesis: why would some ship owners support speed limits?

Visible reasons

- Reduce fuel costs
- Reduce GHGs
- Is politically correct

Less visible reasons

- Freight rate increase
- Easier to compete against ships that are more energy efficient

6 MAY 2019

Climate advocates split over shipping speed limits

Published on 06/05/2019, 6:00am

A go-slow at sea would cut fuel use and greenhouse gas emissions fast, but there are concerns it would delay a permanent shift to cleaner technology and fuels

Climate advocates are divided on the best way to cut ship emissions quickly (Pic: Flickr/GrahamAndDairne)

By Megan Darby

European countries are divided on the best way to cut shipping emissions in the short term, submissions ahead of a meeting at the International Maritime Organisation (IMO) this week show.

France and Greece back speed limits at sea as a way to slash fuel consumption in the existing fleet that could deliver results before 2023. More than one

The extended lobby

- France
- Greece
- Greenpeace
- Various environmental groups

- >100 shipping companies (many of them Greek)

7 MAY 2019

TradeWinds poll: clear backing for slow-steaming

61% are for the measure, 39% against

8 MAY 2019

Speed limits will stifle decarbonisation progress, warns Maersk

Imposing speed limits has become the most controversial measure up for discussion at IMO MEPC 74. The world's largest shipping company is not keen to see it come into effect, warning it will simply delay investment in what matters. But not all is lost, according to Maersk, as other proposals to the meeting offer hope

08 May 2019 | **NEWS**

Last week at the IMO

Last week at the IMO

‘Don’t fail your children’: youth demand climate action at UN shipping talks

Published on 07/05/2019, 2:19pm

School striker Noga Levy-Rapoport urged the International Maritime Organization to set speed limits at sea, for the sake of young and future generations

Schoolchildren sent origami boats with messages about climate change to delegates at UN shipping talks (Pic: Campaign against Climate Change)

By Megan Darby

Schoolchildren urged the shipping industry to speed up climate action by slowing down, as talks on how to curb emissions started at the International Maritime Organization on Tuesday.

Last week at the IMO

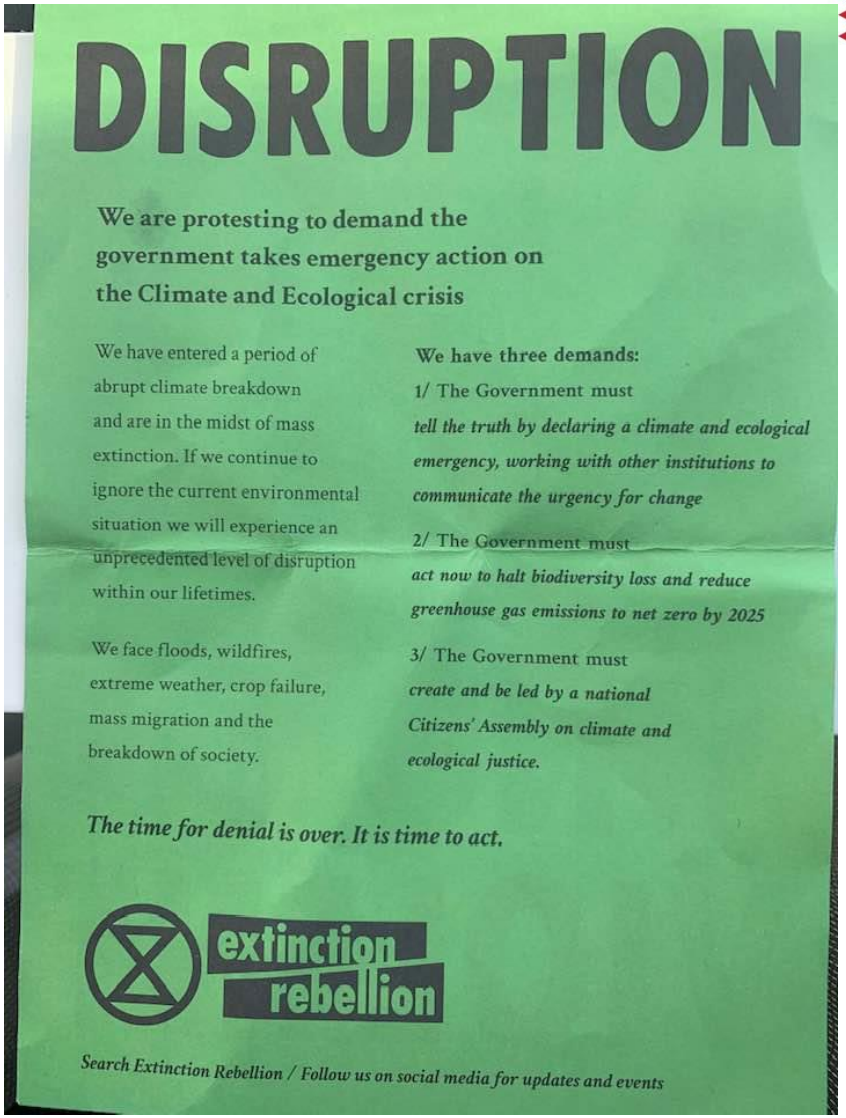
This week at the IMO

This week at the IMO

International Maritime Organization aims to halve global emissions by 2050

▲ Extinction Rebellion activists at the International Maritime Organization in London as delegates arrive. Photograph: Ollie Millington/Getty Images

This week at the IMO



DISRUPTION

We are protesting to demand the government takes emergency action on the Climate and Ecological crisis

We have entered a period of abrupt climate breakdown and are in the midst of mass extinction. If we continue to ignore the current environmental situation we will experience an unprecedented level of disruption within our lifetimes.

We face floods, wildfires, extreme weather, crop failure, mass migration and the breakdown of society.

We have three demands:

1/ The Government must *tell the truth by declaring a climate and ecological emergency, working with other institutions to communicate the urgency for change*

2/ The Government must *act now to halt biodiversity loss and reduce greenhouse gas emissions to net zero by 2025*

3/ The Government must *create and be led by a national Citizens' Assembly on climate and ecological justice.*

The time for denial is over. It is time to act.

extinction rebellion

Search Extinction Rebellion / Follow us on social media for updates and events

This week at the IMO

Recall that

- Chile and Peru objected to **”speed reduction”** as a measure.
- Argued that sending cherries to China would suffer.
- Suggested using **”speed optimization”** instead

Compromise solution:

Include both!

.4 consider and analyse the use of speed optimization and speed reduction as a measure, taking into account safety issues, distance travelled, distortion of the market or trade and that such measure does not impact on shipping's capability to serve remote geographic areas;

- **But, no one is really sure what is meant by speed optimization!**

ALSO: wide confusion on what is meant by speed reduction!

Speed reduction can be:

- Voluntary (slow steaming)
- Outcome of a speed limit
- Outcome of a bunker levy

ALSO: wide confusion on what is meant by speed reduction!

Speed reduction can be:

- Voluntary (slow steaming)
- Outcome of a speed limit
- Outcome of a bunker levy

- All these are very different!

- Focus on speed reduction **as an outcome** may shift regulatory focus

Definition of ”speed optimization”

Ship Energy Efficiency Management Plan- SEEMP (IMO, 2011)

“Speed optimization can produce significant savings. However, **optimum speed means the speed at which the fuel used per tonne mile is at a minimum level for that voyage**. It does not mean minimum speed; in fact, sailing at less than optimum speed will consume more fuel rather than less. Reference should be made to the engine manufacturer's power/consumption curve and the ship's propeller curve. Possible adverse consequences of slow speed operation may include increased vibration and problems with soot deposits in combustion chambers and exhaust systems. These possible consequences should be taken into account.”

MAY ADD TO THE CONFUSION

The MS definition

Speed optimization can be defined as the **selection of an appropriate speed profile for the ship so as to optimize a specific objective while meeting various requirements (or constraints)** on the ship's operation. The speeds that correspond to the chosen speed profile are called "optimal speeds".

Typical objective: depends on who pays for the fuel

Ship owner

- MAX PROFIT/DAY

Time charterer

- MIN COST/DAY

OBJECTIVE CAN BE ANY OTHER, APPROPRIATELY DEFINED

CONSTRAINTS

- Time windows
- Scheduling or timetabling requirements
- Constraints on hull stresses, accelerations, etc

3 LEVELS IN SPEED OPTIMIZATION

- OPERATIONAL
- Weather routing
- TACTICAL
- Select speeds at various legs
- STRATEGIC
- Select design speed

SLOW STEAMING: A VOLUNTARY PRACTICE

CONTAINERS

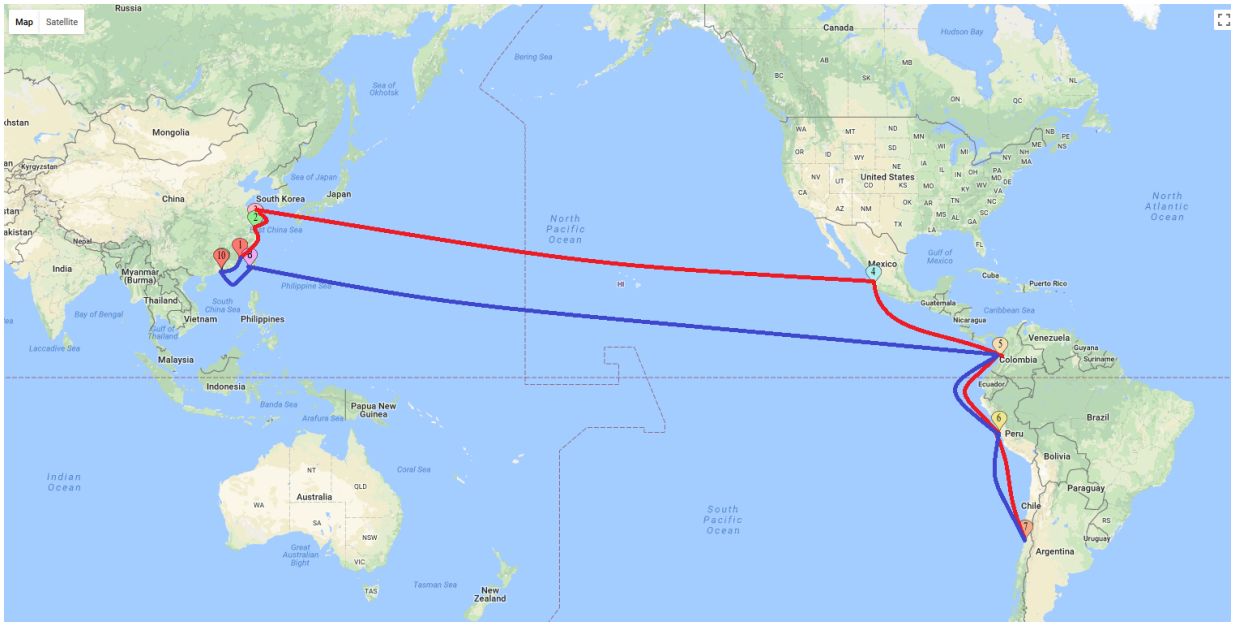
- Recently (2016), UNCTAD documented a **continuing sluggish demand challenged by an accelerated massive global expansion in container supply capacity**, estimated at 8% in 2015—its highest level since 2010.
- Even more recently (2018), the two largest container carriers, Maersk and MSC, have agreed to **further slow steam to cut costs, with some speeds as low as 13 knots!**

SLOW STEAMING: A VOLUNTARY PRACTICE

OTHER SECTORS

- On a global scale, and according to the third GHG study of the IMO, the reduction of global maritime CO_2 emissions from 885 million tonnes in 2007 to 796 million tonnes in 2012 is mainly attributed to **slow steaming due to the serious slump in the shipping markets after 2008**.

Case study



Source: ShipCLEAN project (2018)

Vessels deployed in a TransPacific service

EASTBOUND: Xiamen, Ningbo, Shanghai, Manzanillo, Buenaventura, Callao, San Antonio

WESTBOUND: Callao, Manzanillo, Kaohsiung, Yantian, Hong Kong, Xiamen

Focus – Containership
EXPRESS BERLIN

Built in 2011
Design speed: 25.2 knots
Chartered for: YANG MING LINE (previously: HANJIN)

Main Engine Power 68600 kW
10100 TEU
1400 reefers

More Info on the Service

Average service speed: 15.9 knots
Corresponds to about 18.5% of MCR!

Maximum Continuous Rating
(max engine power)

25% MCR: 17 knots
50% MCR: 22 knots
75% MCR: 25.2 knots
100% MCR: 27.7 knots

10% MCR: 12.6 knots

More Info on the Service

Average service speed: 15.9 knots
Corresponds to about 18.5% of MCR!

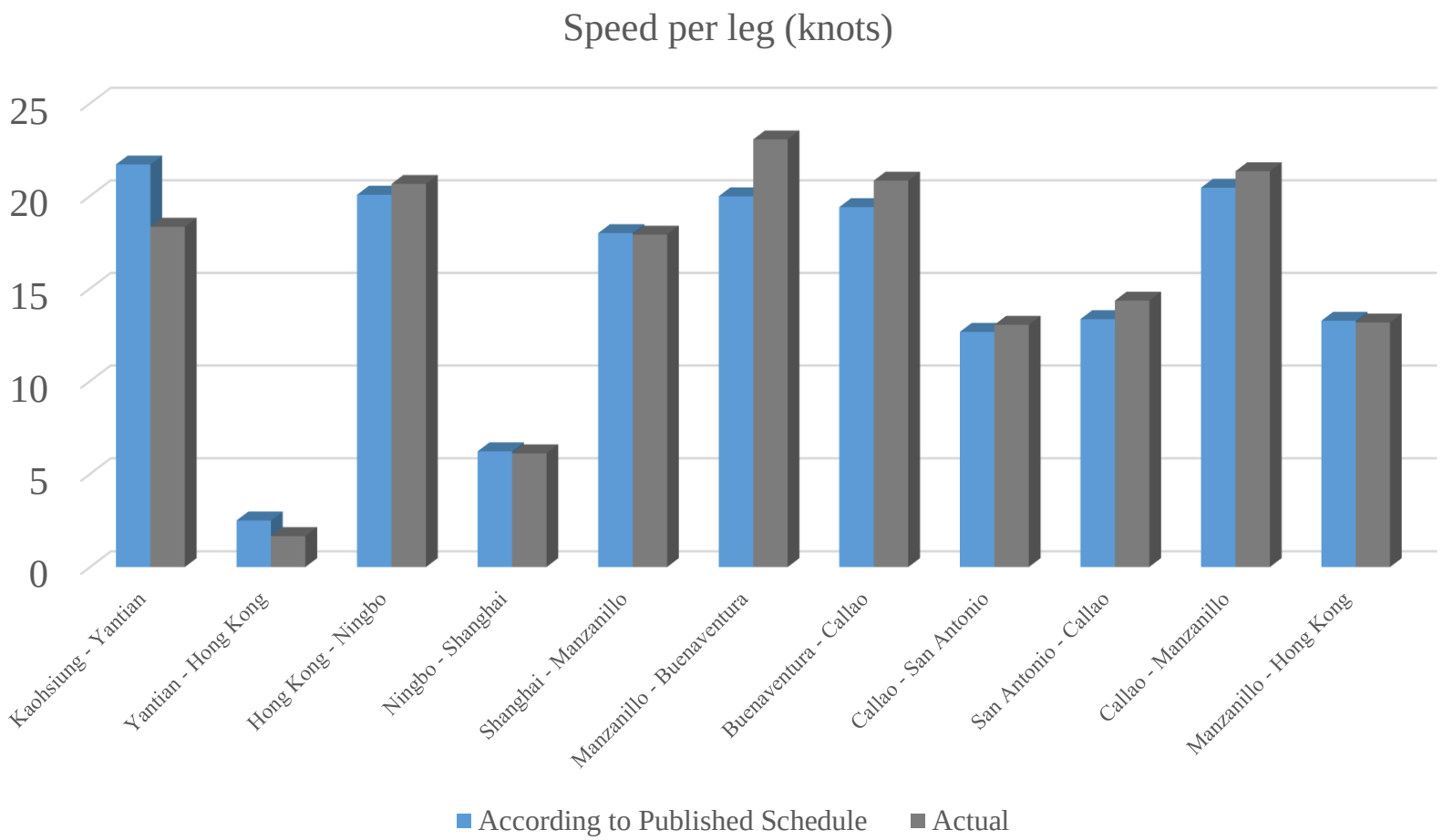
25% MCR: 17 knots
50% MCR: 22 knots
75% MCR: 25.2 knots
100% MCR: 27.7 knots

10% MCR: 12.6 knots

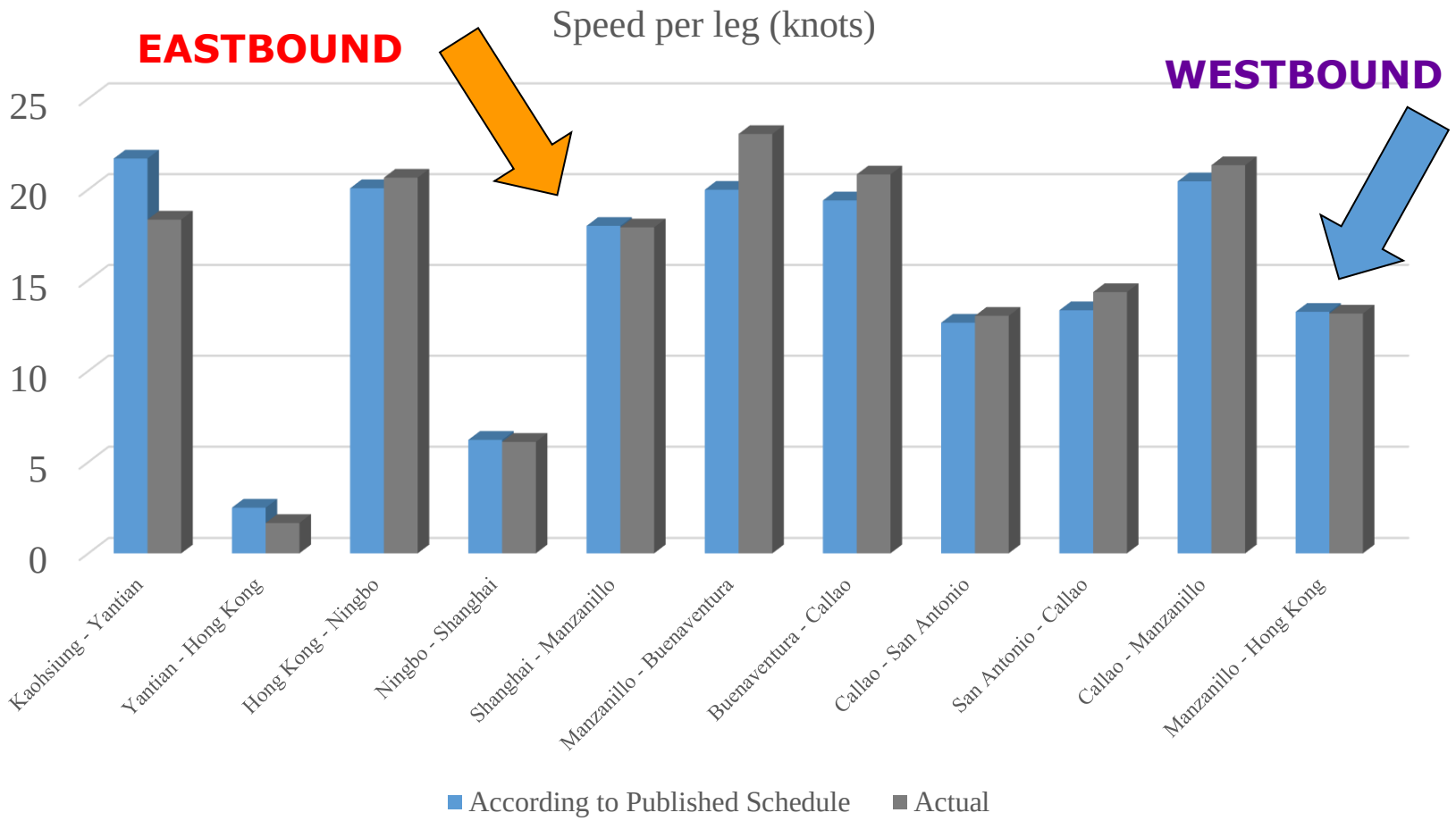
Maximum Continuous Rating
(max engine power)

1st OBSERVATION: SLOW STEAMING BIG TIME!

2nd observation: speed profile



2nd observation: speed profile



Speed imbalances

Source: ShipCLEAN project (2018)

EASTBOUND: Xiamen, Ningbo, Shanghai, Manzanillo, Buenaventura, Callao, San Antonio

WESTBOUND: Callao, Manzanillo, Kaohsiung, Yantian, Hong Kong, Xiamen

How can one explain speed imbalances?

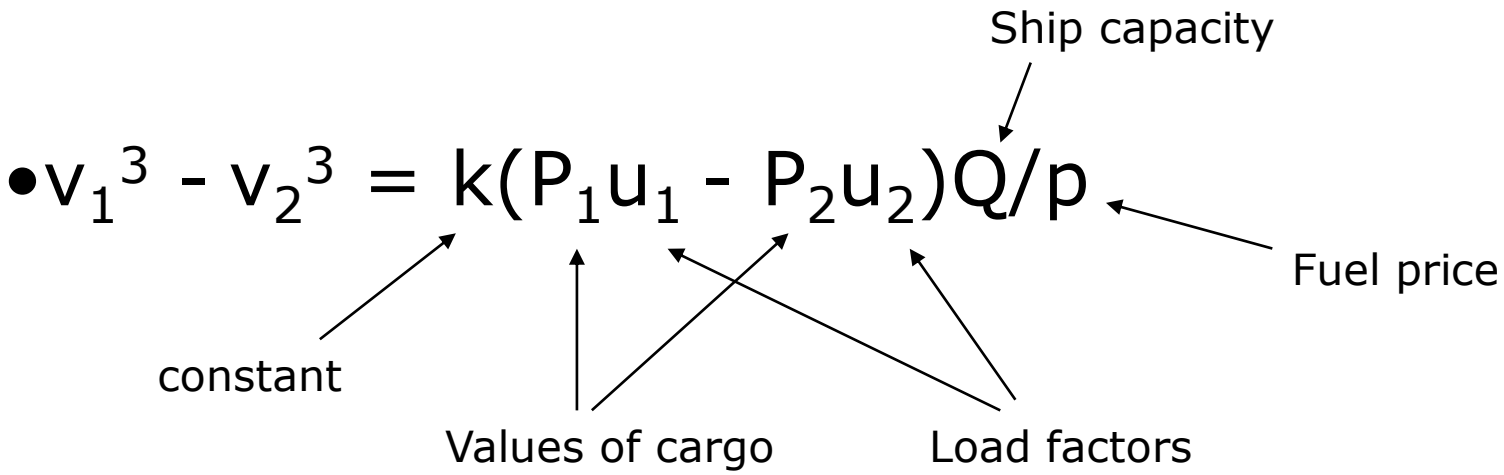
How can one explain speed imbalances?

- (Commercial) factors:

- Difference in values of cargo
- Difference in load factors

- More expensive cargoes sail faster
- Fuller ships sail faster

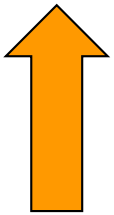
Can be shown that



CO2 reductions, speed limit

Table 4. Reductions of CO_2 and other attributes as a function of the speed limit V, constant throughput.

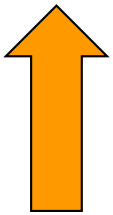
V (Knots)	18.00	20.00	22.00
v_{opt} (knots)	18.00	20.00	22.00
T (days)	92.59	83.33	75.76
C (USD)	5,040,279	5,757,889	6,590,909
I (USD)	18,000,000	18,000,000	18,000,000
P (USD)	12,959,721	12,242,111	11,409,091
r	1.28	1.15	1.05
P′ (USD/day)	179,418	169,483	157,951
CO_2 (tonnes/day)	314.43	388.18	469.70
ΔCO_2 (tonnes/day)	202.24	128.49	46.97
% ΔCO_2	39%	25%	9%



CO2 reductions, levy

Table 5. Reductions of CO_2 and other attributes as a function of the levy q, constant throughput.

q (USD/Tonne)	100	300	500
v_{opt} (knots)	21.06	18.24	16.32
T (days)	79.13	91.37	102.15
C (USD/rtrip)	7,186,893	7,370,506	7,532,272
I (USD/rtrip)	18,000,000	18,000,000	18,000,000
P (USD/rtrip)	10,813,107	10,629,494	10,467,728
r	1.10	1.27	1.41
P′ (USD/day)	149,723	147,169	144,880
CO_2 (tonnes/day)	430.62	322.94	258.27
ΔCO_2 (tonnes/day)	86.05	193.73	258.40
% ΔCO_2	17%	37%	50%



Important note!

A bunker levy is NOT explicitly included in the set of measures currently considered by the IMO

Only *obliquely* included under **medium term measures (2023-2030):**

.3 new/innovative emission reduction mechanism(s), possibly including Market-based Measures (MBMs), to incentivize GHG emission reduction;

Comparison speed limit vs levy

ISSUE	Speed limit	Speed optimization (with bunker levy)
Timing of measure within IMO Initial Strategy	Short-term	Medium-term
Reduce GHG emissions	Yes	Yes
Apply the polluters pay principle	No	Yes
Internalize the external costs of GHG emissions	No	Yes
Collect monies for out-of-sector emissions reductions, LDCs or SIDS	No	Yes
Short term effect: freight rate increase	Yes	Yes

Comparison speed limit vs levy ii

ISSUE	Speed limit	Speed optimization (with bunker levy)
Long term effect: build more ships	Yes	Yes (less pronounced)
Market distortions	Considerable	None
Increase in lifecycle GHG emissions	Higher	Lower
Burden to administer	Considerable	Low
Enforcement	Difficult to impossible	Tractable
Incentive to economize and improve efficiency	No	Yes
Compatible with virtual arrival	No	Yes

Most important

- Speed limit would provide no incentive to develop the new fuels and energy saving technologies that would significantly reduce GHGs
- Would penalize energy efficient ships by forcing them to sail at the same speed with their inefficient competitors

Other GHG-related issues

- Consider concrete proposals for assessing the impacts on States with a view to the finalization of the procedure, noting the discussion at ISWG-GHG 4 on impacts on States;
- Finalize the draft terms of reference for the Fourth IMO GHG Study with a view to approval at MEPC 74;
- Consider concrete proposals on candidate short-term measures, noting the discussion at ISWG-GHG 4 about short-term measures and their categorization;
- Consider concrete proposals on candidate mid-/long-term measures, noting the discussion at ISWG-GHG 4 about mid-/long-term measures and action to address the identified barriers;
- Initiate the development of further actions on capacity-building, technical cooperation, research and development, including support for assessment of impacts and support for implementation of measures; and
- Submit an oral status report to MEPC 74 on Monday, 13 May 2019 and a written report in conjunction with the report of the Working Group to be established at MEPC 74.

Other GHG-related issues

- Consider concrete proposals for assessing the impacts on States with a view to the finalization of the procedure, noting the discussion at ISWG-GHG 4 on impacts on States;
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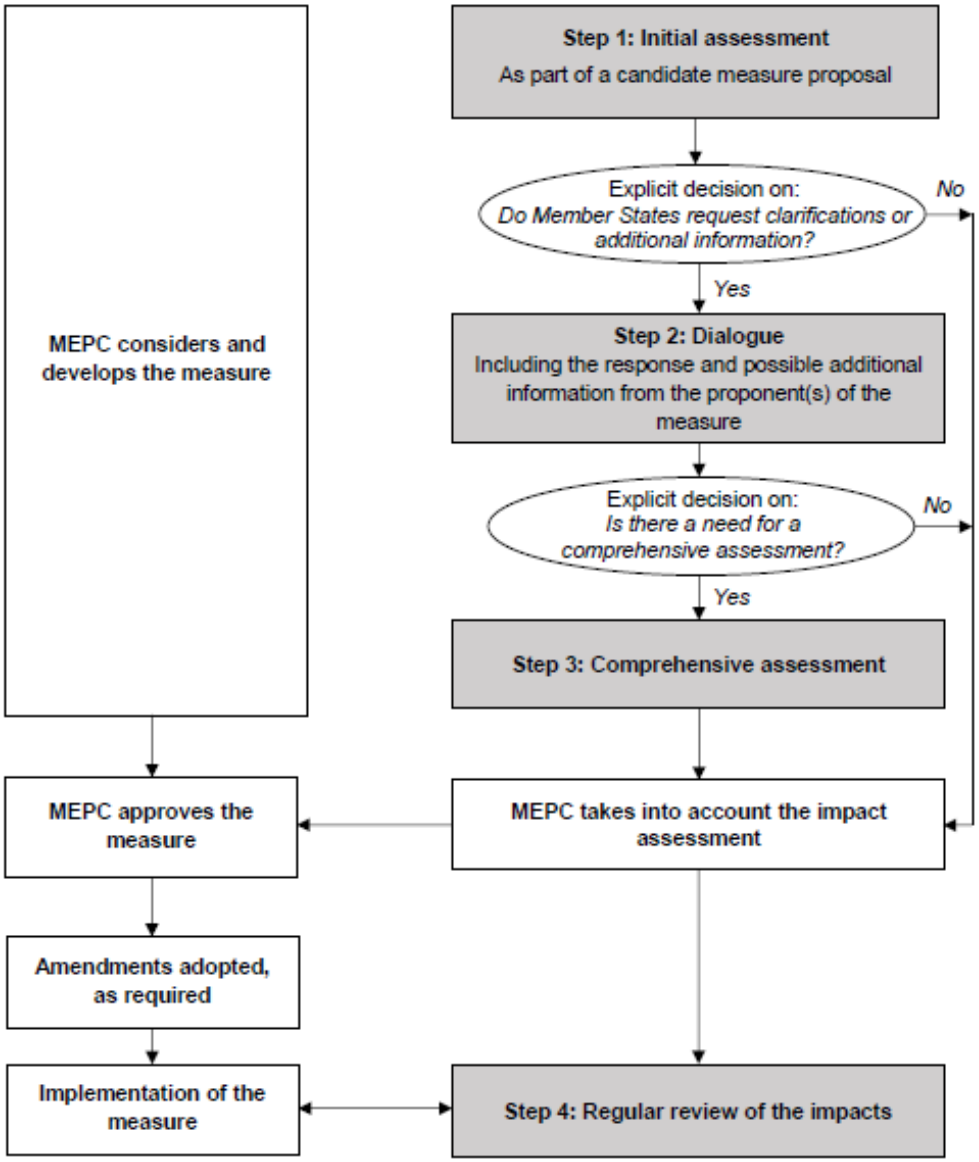
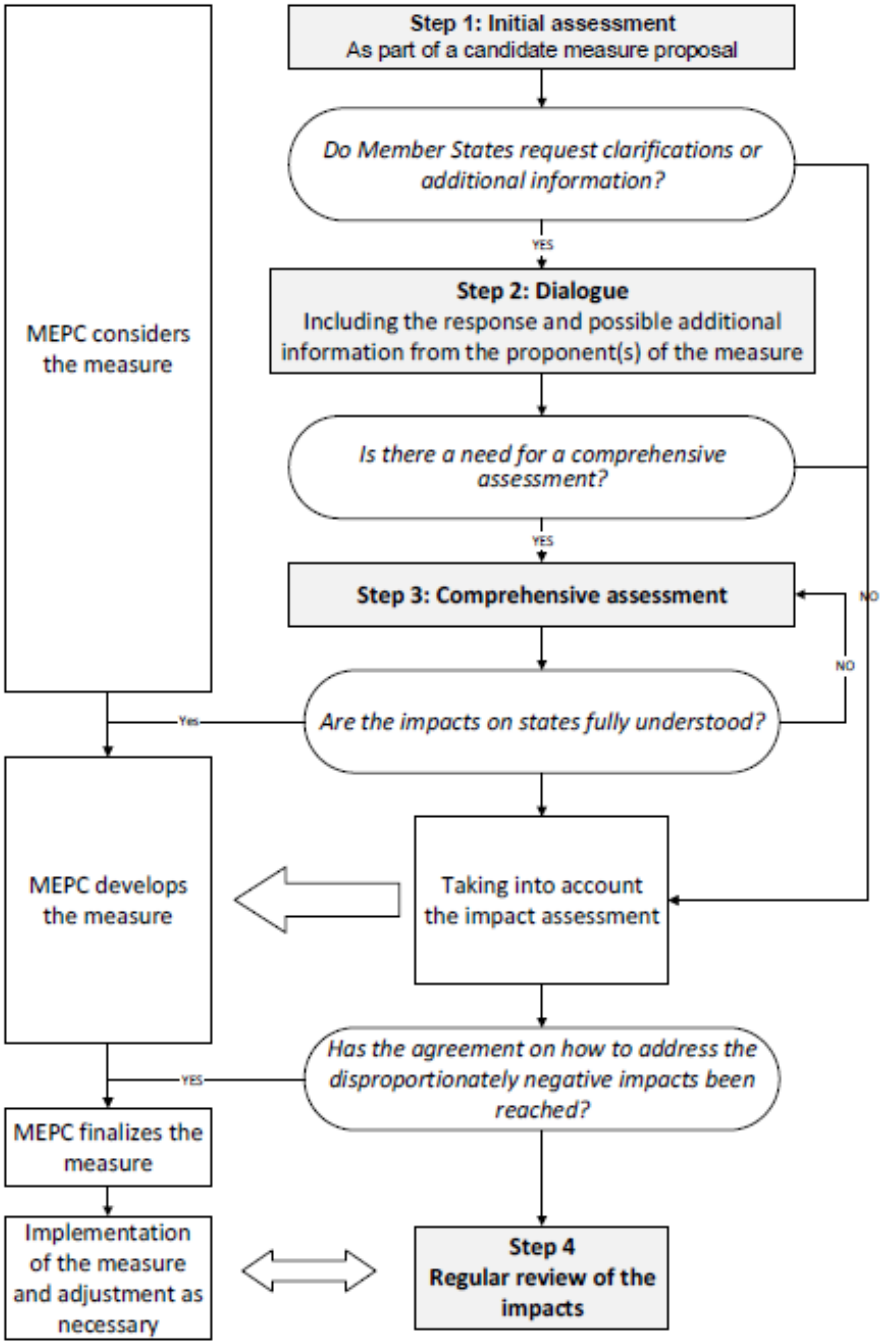
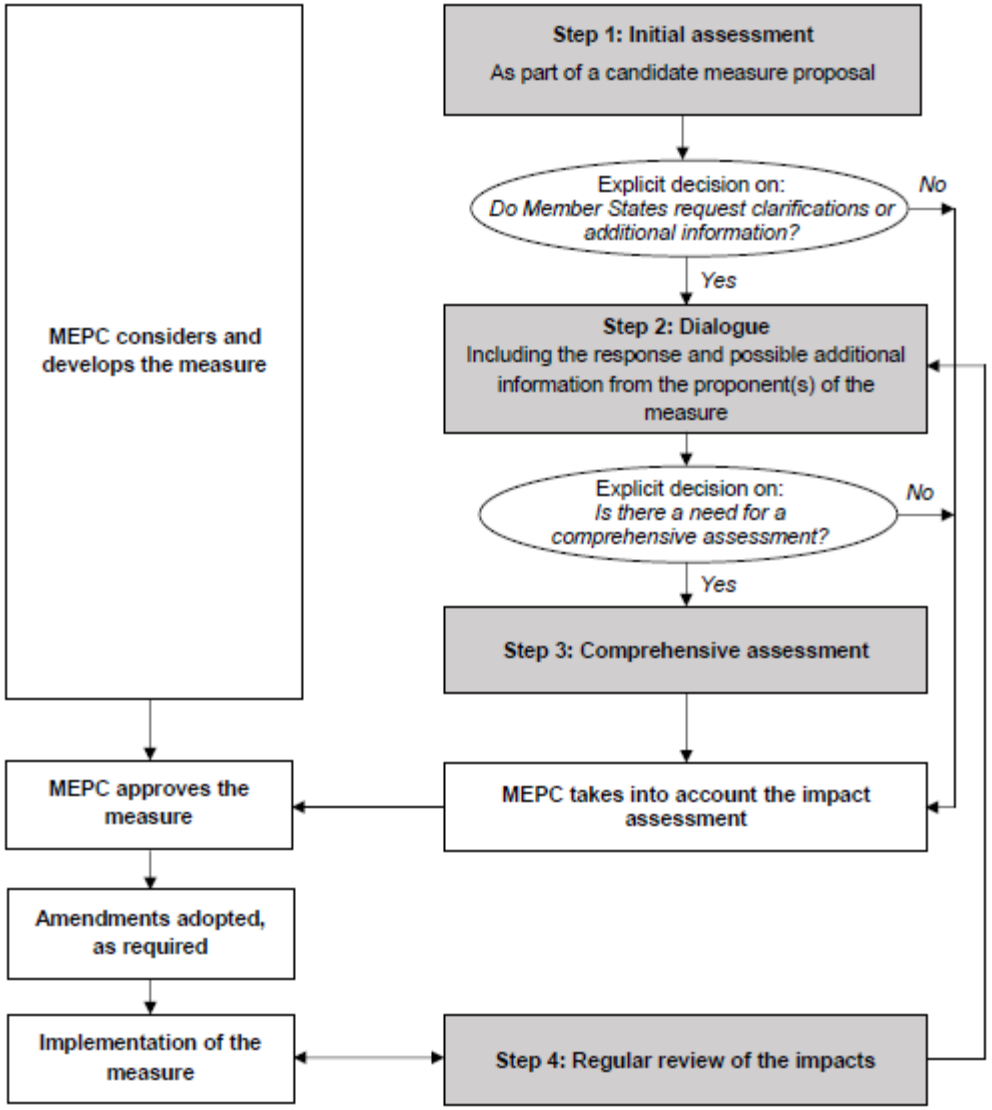
PROPOSAL A: initial proposal in document ISWG-GHG 5/J/3



PROPOSAL B, as proposed by China:



PROPOSAL C, as proposed by the Republic of Korea:



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Is ANY decision on speed limits likely?

- ADOPT
- REJECT
- CONTINUE DISCUSSION

Is ANY decision on speed limits likely?

- ADOPT
- REJECT
- CONTINUE DISCUSSION

- (remember, IMO only has to **consider** measures!)

Personal opinion

- **BIG MESS** if speed limits are adopted
- I do not see it coming

Appendix: Speed papers

Name	Date modified	Type	Size
2010 Psaraftis Kontovas	1/15/2018 2:42 PM	Adobe Acrobat D...	178 KB
2011a Kontovas Psaraftis	1/15/2018 2:43 PM	Adobe Acrobat D...	865 KB
2011b Kontovas Psaratis	6/1/2013 4:04 PM	Adobe Acrobat D...	335 KB
2012 Gkonis Psaraftis	8/26/2013 6:20 AM	Adobe Acrobat D...	1,542 KB
2013 Psaraftis Kontovas	12/8/2012 11:12 AM	Adobe Acrobat D...	1,557 KB
2014 Kapetanis et al	10/21/2014 3:17 PM	Adobe Acrobat D...	228 KB
2014 Psaraftis Kontovas	1/15/2018 2:37 PM	Adobe Acrobat D...	1,428 KB
2015 Fagerholt et al	1/30/2015 6:14 PM	Adobe Acrobat D...	1,731 KB
2015 Fagerholt Psaraftis	1/15/2018 2:33 PM	Adobe Acrobat D...	968 KB
2015 Magirou et al	1/15/2018 2:35 PM	Adobe Acrobat D...	440 KB
2015 Psaraftis Kontovas SPEED Lee Meng ...	1/19/2019 5:46 PM	Adobe Acrobat D...	977 KB
2016 Psaraftis Kontovas book chapter	10/27/2017 11:12 ...	Adobe Acrobat D...	849 KB
2017 Psaraftis	1/15/2018 2:38 PM	Adobe Acrobat D...	245 KB
2017 Wen et al	1/15/2018 2:34 PM	Adobe Acrobat D...	1,185 KB
2018 Giovannini_Psaraftis	3/26/2019 12:00 PM	Adobe Acrobat D...	1,216 KB
2019 CH 10 from_Book_SustainableShipp...	5/3/2019 12:01 PM	Adobe Acrobat D...	573 KB
2019 Psaraftis Sustainability	4/15/2019 9:00 AM	Adobe Acrobat D...	779 KB

Ship speed and Siberia

Transportation Research Part D 15 (2010) 458–462

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

Balancing the economic and environmental performance of maritime transportation

Harilaos N. Psaraftis *, Christos A. Kontovas

Laboratory for Maritime Transport, National Technical University of Athens, Greece

- Use logit models to estimate modal shifts

Speed taxonomy paper

Transportation Research Part C 26 (2013) 331–351

Contents lists available at SciVerse ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Overview Paper

Speed models for energy-efficient maritime transportation: A taxonomy and survey

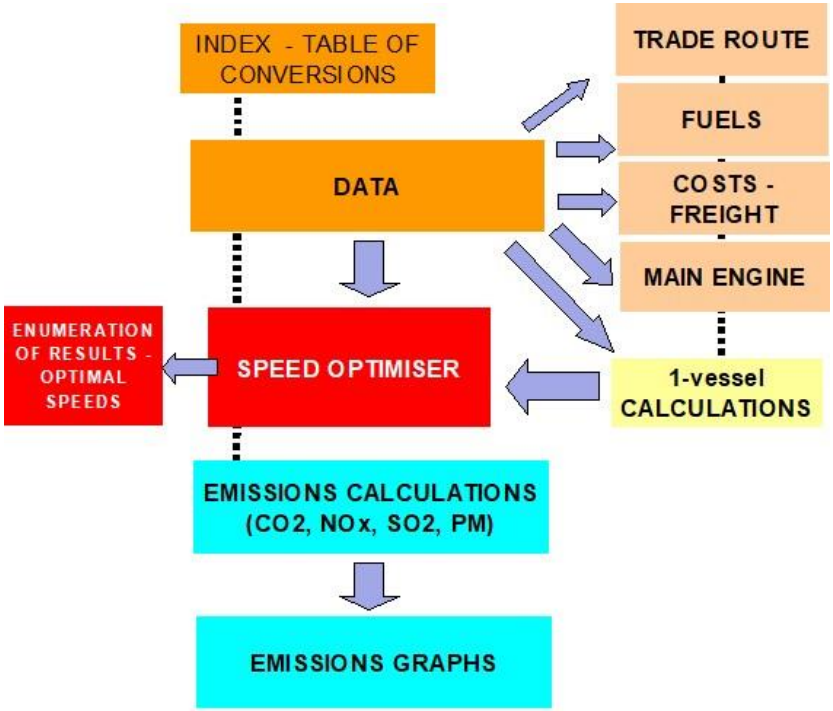
Harilaos N. Psaraftis *, Christos A. Kontovas

Laboratory for Maritime Transport, National Technical University of Athens, Athens, Greece

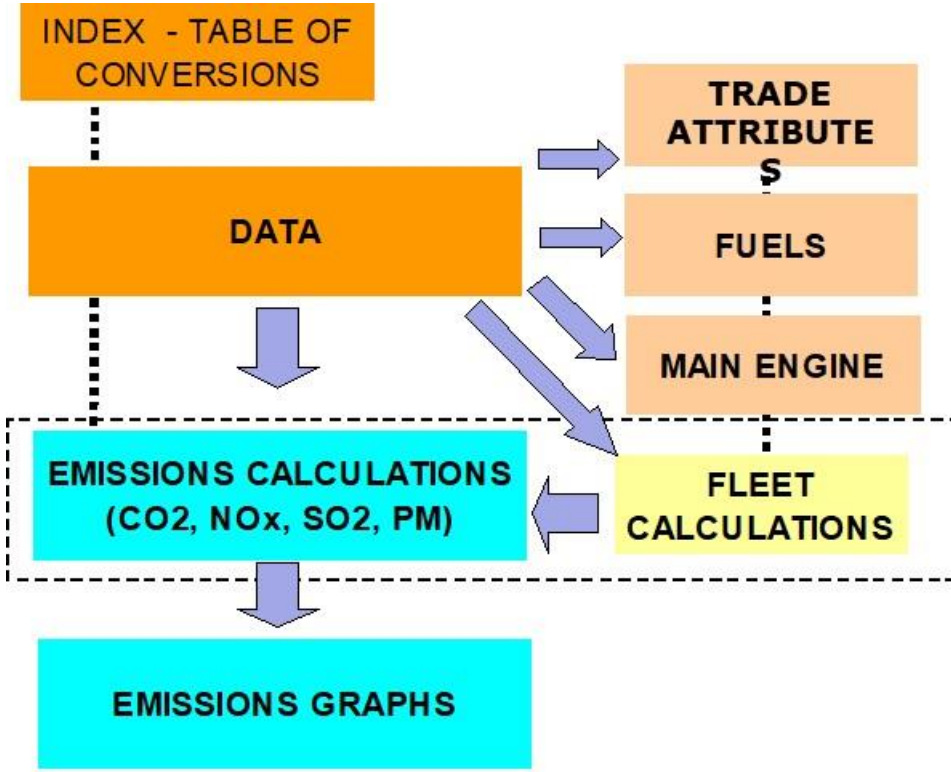
Modeling Tankers' Optimal Speed and Emissions

Konstantinos G. Gkonis (V) **and Harilaos N. Psaraftis** (FL)
Laboratory for Maritime Transport
School of Naval Architecture and Marine Engineering
National Technical University of Athens

- One ship model



- Fleet model



Combining speed and routing decisions

Transportation Research Part C 44 (2014) 52–69

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Ship speed optimization: Concepts, models and combined speed-routing scenarios

Harilaos N. Psaraftis *, Christos A. Kontovas

Department of Transport, Technical University of Denmark, Lyngby, Denmark

Combining speed and routing decisions ii

Transportation Research Part D 52 (2017) 303–321

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

A multiple ship routing and speed optimization problem under time, cost and environmental objectives

M. Wen [a], D. Pacino [b,*], C.A. Kontovas [c], H.N. Psaraftis [b]

[a] Department of Mathematical Science, Xi'an Jiaotong-Liverpool University, 111 Ren Ai Road, Suzhou, Jiangsu 215123, China
[b] Department of Management Engineering, Technical University of Denmark, 2800 Kgs. Lyngby, Denmark
[c] Department of Maritime and Mechanical Engineering, Liverpool John Moores University, L3 3AF Liverpool, United Kingdom

Speed and ECAs (emission control areas)

Transportation Research Part C 52 (2015) 57–73

Contents lists available at ScienceDirect

Transportation Research Part C

journal homepage: www.elsevier.com/locate/trc

Maritime routing and speed optimization with emission control areas

Kjetil Fagerholt [a,*], Nora T. Gausel [a], Jørgen G. Rakke [b], Harilaos N. Psaraftis [c]

[a] Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Trondheim, Norway
[b] Norwegian Marine Technology Research Institute (MARINTEK), Trondheim, Norway
[c] Department of Transport, Technical University of Denmark, Lyngby, Denmark

Speed and ECAs ii

Transportation Research Part D 39 (2015) 56–64

Contents lists available at ScienceDirect

Transportation Research Part D

journal homepage: www.elsevier.com/locate/trd

On two speed optimization problems for ships that sail in and out of emission control areas

Kjetil Fagerholt [a,b], Harilaos N. Psaraftis [c,*]

[a] Department of Industrial Economics and Technology Management, Norwegian University of Science and Technology, Trondheim, Norway
[b] Norwegian Marine Technology Research Institute (MARINTEK), Trondheim, Norway
[c] Department of Transport, Technical University of Denmark, Lyngby, Denmark

Dynamic speed

Transportation Research Part B 76 (2015) 48–67

Contents lists available at ScienceDirect

Transportation Research Part B

journal homepage: www.elsevier.com/locate/trb

The economic speed of an oceangoing vessel in a dynamic setting

Evangelos F. Magirou [a,*], Harilaos N. Psaraftis [b], Theodore Bouritas [a]

[a] Athens University of Economics and Business, Department of Informatics, Patission 76, Athens 10434, Greece
[b] Technical University of Denmark, Department of Transport, Bygningstorvet 1, 2800 Kgs. Lyngby, Denmark

Speed with flexible frequencies

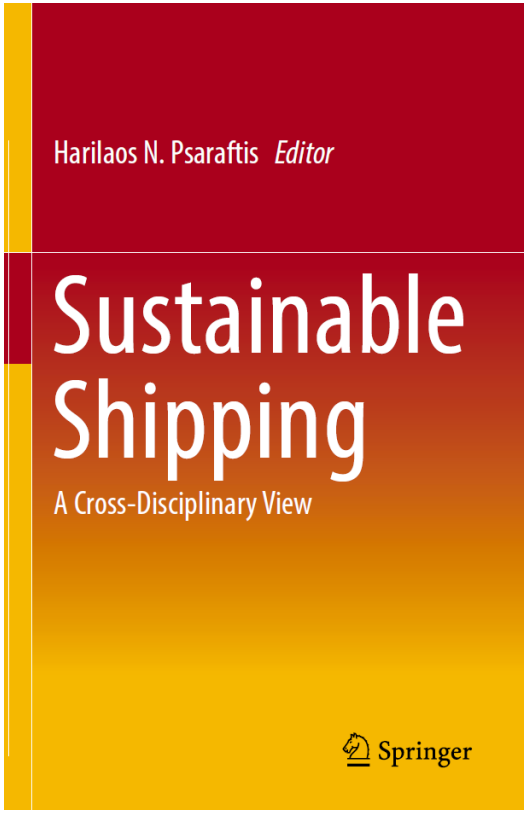
Flex Serv Manuf J
https://doi.org/10.1007/s10696-018-9308-z

CrossMark

The profit maximizing liner shipping problem with flexible frequencies: logistical and environmental considerations

Massimo Giovannini[1] · Harilaos N. Psaraftis[2]

Most recently



Chapter 10
Speed Optimization for Sustainable Shipping

Harilaos N. Psaraftis

Latest

Article

Speed Optimization vs Speed Reduction: the Choice between Speed Limits and a Bunker Levy

Harilaos N. Psaraftis

DTU Management, Technical University of Denmark, 2800 Lyngby, Denmark; hnpsar@dtu.dk

Received: 18 March 2019; Accepted: 10 April 2019; Published: 15 April 2019

THANK YOU

hnpsar@dtu.dk